PGA103+ Low noise, high dynamic range preamp for VHF and UHF

by Sam Jewell, G4DDK

Introduction

I was recently alerted to a new low noise, high dynamic range, PHEMT MMIC by WA5VJB. The PGA103+ from MCL claims sub 0.5dB noise figure (NF) at 144MHz and better than 0.55dB at 432MHz. It should also provide around 0.8dB NF at 1296MHz.The gain at 144MHz is around 26dB and 25dB at 432MHz. Although MCL claim that the device is useable from 50MHz to 4000MHz, I have found that it is perfectly useable down to at least 30MHz by using a larger value input coupling capacitor. I wrote about this device in my November RSGB Radcom *GHz Bands* column, where I mounted the SOT89 packaged device on a surplus evaluation PCB I had available. My initial results with the PGA103+ confirmed the MCL claims to my satisfaction. Since then WA5VJB has provided me with some low loss Arlon PCBs for this same device. I assembled one of the PCBs and housed it in one of Schubert's (www.schubert-geheuse.de) tin plate boxes to provide screening. With this I was able to make some more measurements and these confirm the excellent VHF noise figure and dynamic range claims. Several more kits were distributed in the UK, HB9 and DL. The results from these also confirm the excellent performance of this amplifier.

Circuit schematic and assembly

The schematic really could not be simpler. The PCB is designed to accept 0603 size SMD parts except for the drain bias resistor which is a standard 1/4 W 4.7Ω leaded resistor to allow for extra dissipation since the device draws around 84mA at 4.5-5V. The initial PCBs are designed for cable termination input, but SMA through-board PCBs may also be available in the New Year. Figure 1 shows the circuit schematic of the PGA103+ amplifier. Photo 1 shows the component layout. Table 1 gives the component values.

Component	Value	Package
R1	4.7Ω	Leaded 1/4 W
C1,3,4	1000pF	SMD0603
C2	100pF	SMD0603
C5	1µF	Case A size
L1	270nH	1618
IC1	PGA103+	SOT89

Table 1

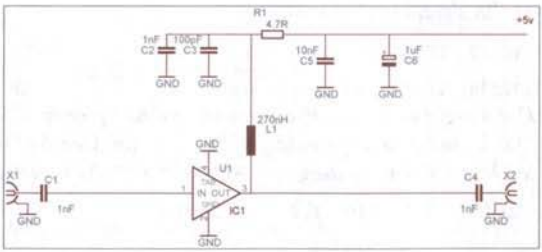

Fig. 1: Circuit diagram

Box

The PGA AMP fits comfortably into one of the Schubert tin plate boxes. I chose to use the 20mm x 20mm x 55mm size with BNC cut out at the ends (FG2B). These boxes are available in the UK from G3NYK and in Germany from Eisch Electronic. The board will also fit into the smaller 20mm x 20mm x 37mm size box but there is less room to manoeuvre the output coaxial cable. Schubert (as far as I know) do not make the box with SMA connector size cut outs. However, soldering four-hole size SMA connectors over the BNC cut out, the flange of the SMA connector nicely covers up the larger BNC entry size hole. The connectors could be BNC, if preferred. There are many ways to mount the PCB in the box. I chose to solder the board in vertically and make a short wire link from the SMA spill to the PCB input. The output uses a short length of PTFE coaxial cable between the PCB and the output SMA connector.

For use at 23cm (and you might wish to consider the PGA103+ for use in a contest station environment at 23cm because of its outstanding dynamic range) it might be better to cut the input end off the PCB and solder direct between the input track and the connector spill, with the ground-plane of the PCB soldered to the end wall of the box to maintain grounding integrity. I chose to solder a 78M05 5V/500mA SMD regulator to the ground-plane side of the PCB with 10µF/20V working tantalum capacitors for decoupling. This ensures that whatever the input supply voltage variation, no more than +5V appears at the PGAAMP. I used a Tusonix 1500pF solder-in feed-through capacitor to bring the supply into the box. My prototype PGA AMP is shown in photo 2.

Results

Table 2 shows the results of my measurements on the prototype boxed PGA AMP. The usual caveats apply, i.e. systematic uncertainties in the measurements, particularly of the noise figures, test equipment calibration , quoting noise figures to hundredths of a dB! etc.

Frequency (MHz)	Noise figure (dB)	Insertion gain (dB)	Input IP3 (dBm)	Input return loss (dB)	Output return loss (dB)	Psat Output (dBm)
30	0.5	26.2				
50	0.5	26.2		3.8		
70	0.5	25.9		5.2		22.1
144	0.46	25.2	+11.8	8.7	22	22.5
432	0.52	21.6	+10.5	10.6		
1296	0.8	14.1	+20.5	14.7	15.4	24.5

Table 2

Summary

I have not seen a sub 0.5dB noise figure 144MHz preamplifier with as high an IIP3 as +12dBm before. An IIP3 of +10.5dBm at 432MHz is also pretty impressive for a device delivering over 20dB of gain and around 0.5dB noise figure. At 1296MHz the IIP3 is also extremely good at over +20dBm. However, this figure could be improved significantly by careful selection of the device operating point. Potentially, it could be as high as +26 to +30dBm. These are the numbers achieved at 1.9GHz in the original cellular radio base station mast head preamplifier application of this device. One of the advantages of this small high performance amplifier is that it is so small that it can be fitted inside many existing transceivers as an alternative receiver front end, possibly giving a large increase in receiver performance. A concern of many 144MHz band users is strong signal effects from Band 2 FM broadcast stations. However, unless you live or operate very close to one of these monsters they probably don't cause the average radio amateur any problem. Traditionally, the input selectivity provided by low loss input matching circuits has been used to reduce the effects of FM broadcast stations. These 'filters' are not always as effective as we might imagine! In the PGA AMP the very high IIP3 provides additional protection against Band 2 broadcast signals as well as against close-in paging signals and some in-band signals from the bigger contest stations. Where additional protection from Band 2 is required a simple high pass filter can be used at the PGA AMP input. DJ7VY and LA8AK (SK) both recommended this approach as it can give extremely low losses at the preamplifier input (<0.13dB) together with close on 50dB rejection of the more troublesome stations in Band 2. I recommend the DJ7VY 130MHz HPF design (VHF Comms, Vol. 10, Spring 1/1978), although this is now known not to be an optimum design. G4SWX and myself have been designing slightly lower loss, practical, alternative HPFs for this purpose. It may be convenient to build the HPF into a separate box from the preamp and only connect it if it is required. Indeed you would have a few problems fitting the DJ7VY HPF into the same Schubert box as the preamp. Most 144MHz operators should not find it necessary to use the filter. Filtering above 144MHz is probably best left to a low loss bandpass filter located at the preamplifier output, although an input 400MHz HPF might also be practical. Low cost kits for the PGA103+ amplifier should be available from G4DDK in the New Year. Please see my web page www.G4DDK.com 73 de Sam, G4DDK

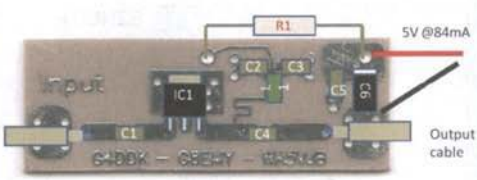

Photo 1

(Red.: DL-Übersetzung erscheint in Kürze im Technik 12 Buch)

Photo 2